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Significance of pH_1 and early rigor for prediction of pork meat quality

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Introduction

Recently, several authors have reported, that low pH_1 does not predict undoubtedly PSE pork quality /Blendl and Puff, 1978; Vada, 1978; Barton, 1978, 1980; Lengerken and Hennebach, 1979/. According to Barton /1978/ correlation between quality traits measured in the slaughter line and ultimate meat quality depended on the pre-slaughter conditions. DFD meat can develop in muscles either in hereditary stress-susceptible or stress-resistant animals after a long term stress /Nielsen, 1980; Monin et al. 1981/. From these results it can be suggested, that relationship between physiological reactions early post mortem and ultimate meat quality required further investigations.
For better identification of ultimate meat quality and for evaluation the importance of slaughter line meat quality traits as predictors of ultimate meat quality, in this study physiological measurements of muscle at 45 min post mortem were related to meat quality traits measured at 24 hr post mortem.

Materials and Methods

pH_1 and pH_{ult}

In a commercial ham factory slaughter line pH was measured in several points of the medial part of m. semimembranosus. INDU-NORM digital pH-meter equipped with combined glass electrode was used. Slices of appr. 200 grams were removed from carcasses for further examinations and were put into plastic bags. Samples were refrigerated from 3 hr post mortem at 4-6 °C. Ultimate pH was measured at 24 hr post mortem. For statistical evaluation means of pH values were used.

R value

R value was determined as described by Honikel and Fischer/1977/ at 1 hr post mortem. Rigidity was subjectively evaluated in slaughter line /rigid; non-rigid/.

Turbidity of sarcoplasmic extract /percent transmission/

Sarcoplasmic extract was prepared at 24 hr post mortem. 7 grams of meat was homogenised /20000 rpm, Ultra-Turrax/ with 4 volumes of distillated water for 4x10 sec at 0°C. After 2 hr of storage at 0°C homogenate was filtered on Macherey-Nagel 615 1/4 filter paper. 10 ml of citrate buffer pH 4.6 was added to 2 ml of filtrate and percent transmission was measured at stationary phase of turbidity at 20° C /VSU-2P spectrophotometer, 600 nm/.

Surface density

At 24 hr post mortem surface density was measured by LOVIBOND TINTOMETER. Density scale reading was established to be equivalent with surface reflectance measured by GÖFO /Losonczy and Antal, 1974/.

Total pigment content was determined according to Hornsey /1956/ and expressed in mg/g wet tissue.

Texture of cooked samples

At 24 hr post mortem 150 grams of minced samples /2-3 cm^3 cubes/ were pressed into cans /5x7 cm/ then cooked for 1 hr at 80° C in ultrathermostat. After overnight standing cans were opened and samples were sliced. Sliceability was subjectively scored: 1=non cohesive, disintegrated; 2=moderately disintegrated; 3=cohesive, firm.

Results and Discussion

Frequency distribution of pH_1 /$pH_1 \geq 5.8$/, $pH_{ult} \geq 5.8$/ and R value of rigid /n=40/ and non-rigid /n=27/ samples are shown in Fig. 1. It can be seen, that in rigid group frequency distribution of pH_{ult} is similar to that of pH_1, which suggest a limited pH change after 45 min post mortem. However, in non-rigid group frequency distribution of pH_1 differs from that of rigid group - a general pH fall can be observed. Differences between pH_1 and pH_{ult} in average were 0.03 and 0.4 pH in the rigid and non-rigid group, respectively.
Frequency distribution of R value are quite different in the two groups /Fig. 1./ - higher values were found in rigid group due to the onset of rigor.
Analysis of discriminance have been performed with R value, pH_1, pH_{ult} between the rigid and non rigid groups. Fig. 2. shows the segregation of rigid and non-rigid samples calculated from the Z-function. Segregation of 81.8% in rigid and 81.8% of non-rigid groups was achieved when all variables were considered. This result shows, that subjective evaluation of rigidity on the carcass proved to be acceptable method for recognition of rigor. From these results it can be concluded, that early rigor together with high pH_1 /$pH_1 \geq 5.8$/ suggest DFD quality /Honikel and Fischer, 1977/, however DFD quality can also develop with slow depletion of ATP and slow pH fall /Várvizi et al., 1981/. It is to be noted, that in our work the majority of rigid DFD samples tended to show lower pH_1 /6.0-5.9/ and also lower pH_{ult}.
For studying the quality of muscles which show rapid pH fall 19 m. semimembranosus with low pH_1

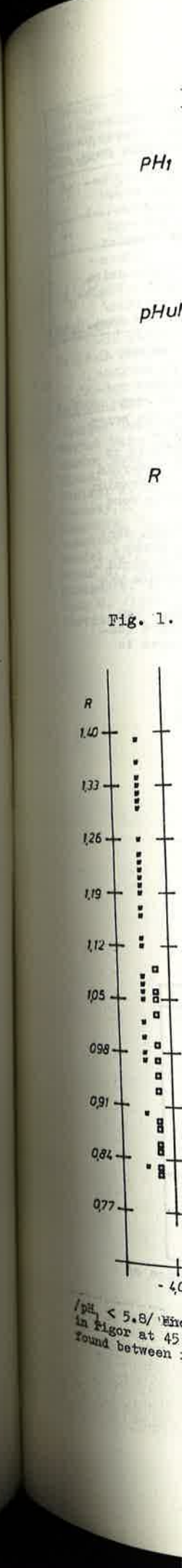

Fig. 1.

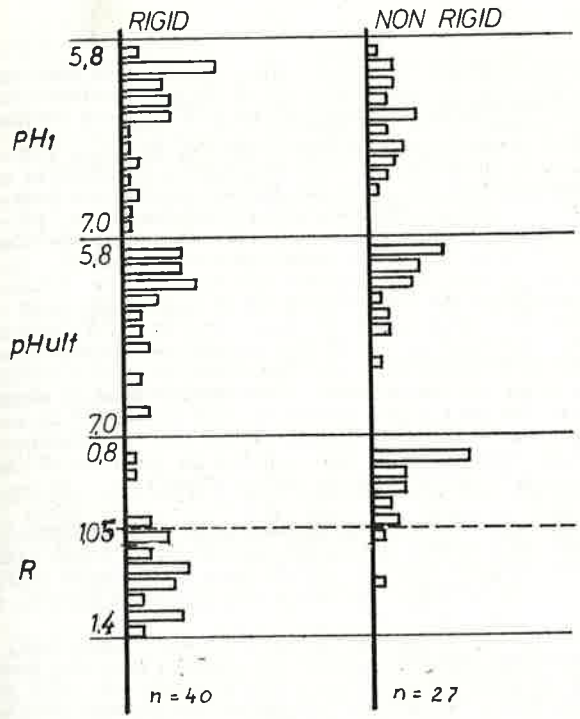

Fig. 1. Frequency distribution of pH_1, pH_{ult} and R_1 value in group of rigid DFD and non-rigid DFD m. semimembranosus samples.

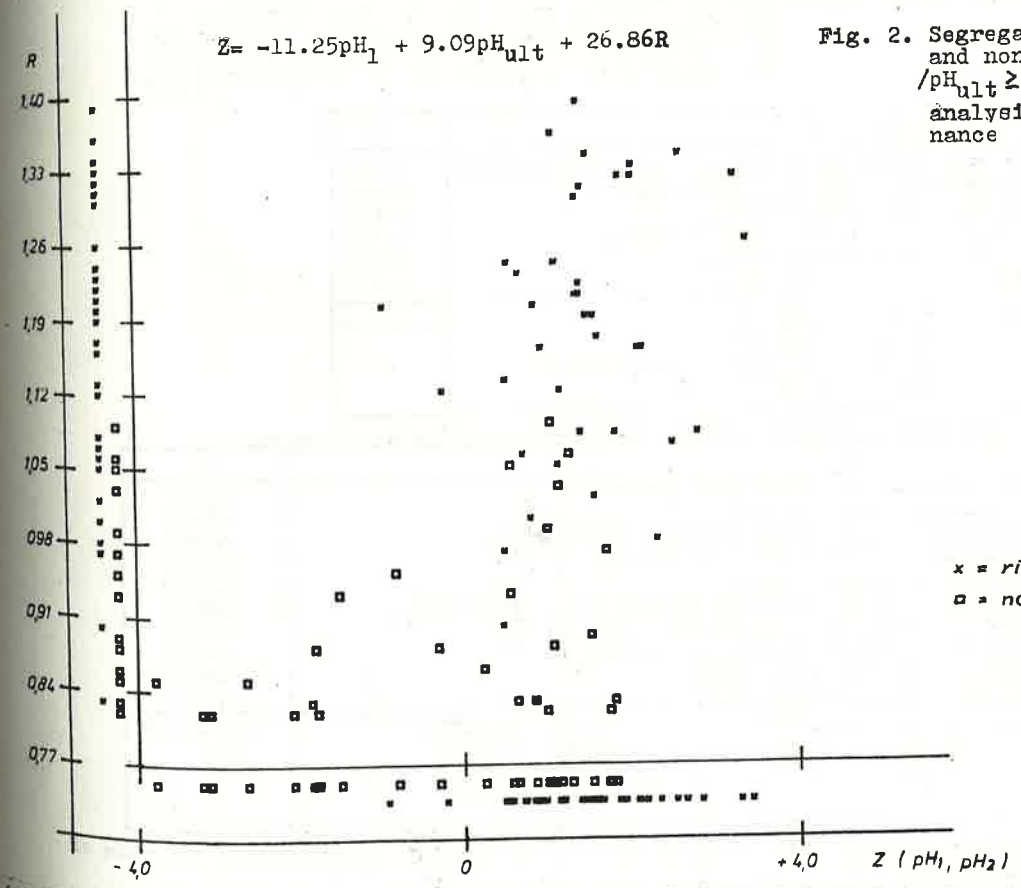

Fig. 2. Segregation of rigid and non rigid samples /$pH_{ult} \geq 5.8$/ by analysis of discriminance

/$pH_1 < 5.8$/ and also 17 samples with high pH_1 /$pH_1 \geq 5.8$/ were tested. Each samples were found to be in rigor at 45 min post mortem. R values were determined of each samples - a close relationship was found between rigidity and R value in accordance with result of analysis of discriminance. For compa-

rison with normal prerigor meat, non-rigid muscle samples of high pH_1 /$pH_1 \geq 5.8$/ also were collected /n=7/. Rigid samples of low pH_1 showed both normal and PSE appearence at 24 hr post mortem. However, only a limited number of PSE muscles were found. Therefore, PSE quality was not analysed in this study.

For identification of those traits, which reflect adequately ultimate quality of meat, quality measurements were compared to each others. In Table 1. stepwise multiple regression analysis is shown between surface density reading as dependent variable and pH_{ult}, total pigment content as independent variables. Stepwise multiple regression analysis is also shown with percent transmission, pH_1 and pH_{ult}. Correlation coefficients of 1. and 3. equations do not differ significantly from the complet form, which includes linear, quadratic forms and interactions of variables /Mandel, 1964/. Surface density seemed to be equally influenced by both pH_{ult} and total pigment content. Percent transmission is influenced by pH_1 and mostly by pH_{ult}, the latter is due to DFD samples of higher pH_{ult}. When DFD samples were excluded, multiple correlation coefficients are lower /Table 2., 1. equation/ as compared to that in Table 1. The 1. 3. and 6. equations do not differ significantly from the complet forms of multiple regression equations. Further omission of variables resulted significantly lower correlation coefficients, except of 4. equation. It can be seen, that surface density seemed to depend only total pigment content in the range of low pH_{ult}. pH_1 seemed to have no effect on surface density /R=o,25 NS, Table 2. 5. equation/. These result suggests /Table 1. and 2./ that surface reflectance does not seem to be a suitable method for evaluation of meat quality in the case of meat with low pH_{ult}. However, percent transmission is still correlated by both pH_1 and pH_{ult} in the range of low pH_{ult}.

In order to assess quality differences between group characterized by physiological measurements at 45 min post mortem /rigid - high pH_1; rigid - low pH_1; normal prerigor/ further statistical analysis was performed with selected traits measured at 24 hr post mortem. On the base of multiple regression analysis surface density, percent transmission and in addition texture score of cooked samples were used for multidimensional F test /Table 3./

When rigid - high pH_1 group was compared to normal prerigor group /1. a,b/, it was established, that surface density combined with percent transmission could differentiate the rigid - high pH_1 group and normal prerigor group, while texture showed neigligable effect. It can be concluded, that rigid - high pH_1 muscles predict DFD quality /Fig. 1. and 2./ which can be characterized by reflectance and transmission at 24 hr post mortem.

The rigid - low pH_1 group significantly differs from the normal prerigor group /Table 3. /2/, when both percent transmission and texture score were considered. It can be concluded, that ultimate quality of muscles, which shows low pH_1 and rigor early post mortem is generally poor as compared to the normal slowly glycolysing muscles with low pH_{ult}.

Equation				R^a
1. Surface density reading=-41.35 +8.94pH_{ult} +7.12 total pigment				o.675
2. Surface density reading= 8.6o +7.oo total pigment				o.454
3. Surface density reading=-29.53 +8.83pH_{ult}				o.493
4. Percent transmission = 26.93 -1.18pH_1 -2.56pH_{ult}				o.759
5. Percent transmission = 25.11 -3.46pH_1				o.717
6. Percent transmission = 19.58 -2.38pH_{ult}				o.628
F of Mandel test	1.-2.	14.14 xxx	xxx=P < o.ool	a=P<o.o5
	1.-3.	11.91 xxx		
	4.-5.	12.11 xxx		
	4.-6.	37.74 xxx		

Table 1. Stepwise multiple regression analysis between meat quality measurements.

Equation					R
1. Surface density reading= 8.29 +6.24 total pigment					o.524^a
2. Surface density reading= 2.82 +3.83 pH_{ult}					o.143^b
3. Surface density reading= -3.57 +2.22 pH_{ult} +5.82 total pigment					o.545^a
4. Surface density reading= 8.45 +6.16 total pigment					o.519^b
5. Surface density reading= -o.54 +3.3o pH_1					o.253^b
6. Percent transmission = -2.93 -1.38 pH_1 +114.7o pH_{ult} -1o.68 pH^2_{ult}					o.61o^a
7. Percent transmission = 19.68 -1.28 pH_1 -o.21 pH^2_{ult}					o.556^a
8. Percent transmission =-245.83+95.34pH_{ult} -9.oopH^2_{ult}					o.477^a
9. Percent transmission = 23.18 -3.o9 pH_{ult}					o.425^a
1o. Percent transmission = 15.5o -1.62 pH_1					o.473^a
F of Mandel test	1.-2.	16.12 xxx	6.-7.	7.69 xx	a=P < o.o5
	3.-4.	3.25 NS	6.-8.	19.1o xxx	b=NS
	3.-5.	18.oo xxx	6.-9.	13.27 xxx	
			6.-1o.	9.8o xx	
xx=P<o.ol xxx=P<o.ool					

Table2. Stepwise multiple regression analysis between meat quality measurements in the range of low ultimate pH.

Groups characterised by physiological measurements at 45 min post mortem		Percent transmission		Texture score		Surface density reading		D^2	F	DF
		$\bar{x}_i d_i$	%	$\bar{x}_i d_i$	%	$\bar{x}_i d_i$	%			
1. R_h - N	a	2.5o	48.5o	-o.o7	-1.3o	2.73	52.8o	5.16	7.75^{xx}	3 22
	b	2.1o	42.36	--	--	2.85	57.64	4.95	$11.7o^{xx}$	2 22
2. R_ℓ - N		o.65	38.7o	1.o4	61.3o	--	--	1.69	4.14^{x}	2 24

x=P < o.o5 xx=P< o.ol

R_h=rigid - high pH_1 /$pH_1 \geq$ 5.8/ R_ℓ=rigid - low pH_1 /pH_1< 5.8/ N=non rigid - {high pH_1 /$pH_1 \geq$ 5.8/ low pH_{ult}

$\bar{x}_i d_i$ =effect of variable

Table 3. Table of multidimensional F test, distribution of variables whithin D^2.

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